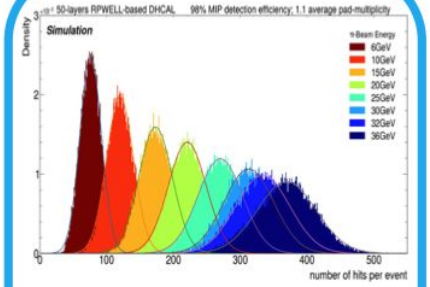
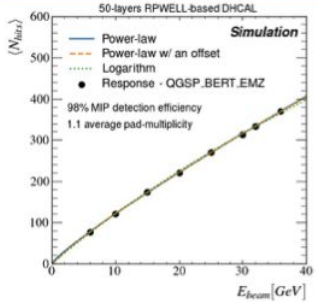
MPGD-HCAL simulation G4

29/04/2022

Energy Reconstruction and Resolution



Extract $\langle N_{hits} \rangle$ per E_{beam}



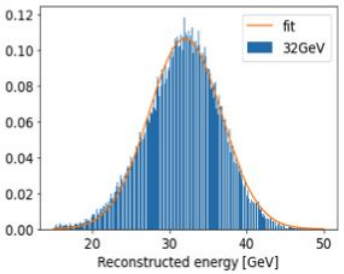
Fit a response function to the described data

$$[1]\ \langle N_{hits} \rangle = a \cdot E_{beam}^{b}$$

$$[2]\ \langle N_{hits} \rangle = a \cdot E_{beam}^{b} - c$$

$$[3]\ \langle N_{hits} \rangle = \frac{a}{b}\log(1 + bE_{beam})$$

[1] CALICE, 2019
[2] Repond, CHEF 2013
[3] Chefdeville, CHEF 2013



Reconstructed energy using the inverse response function

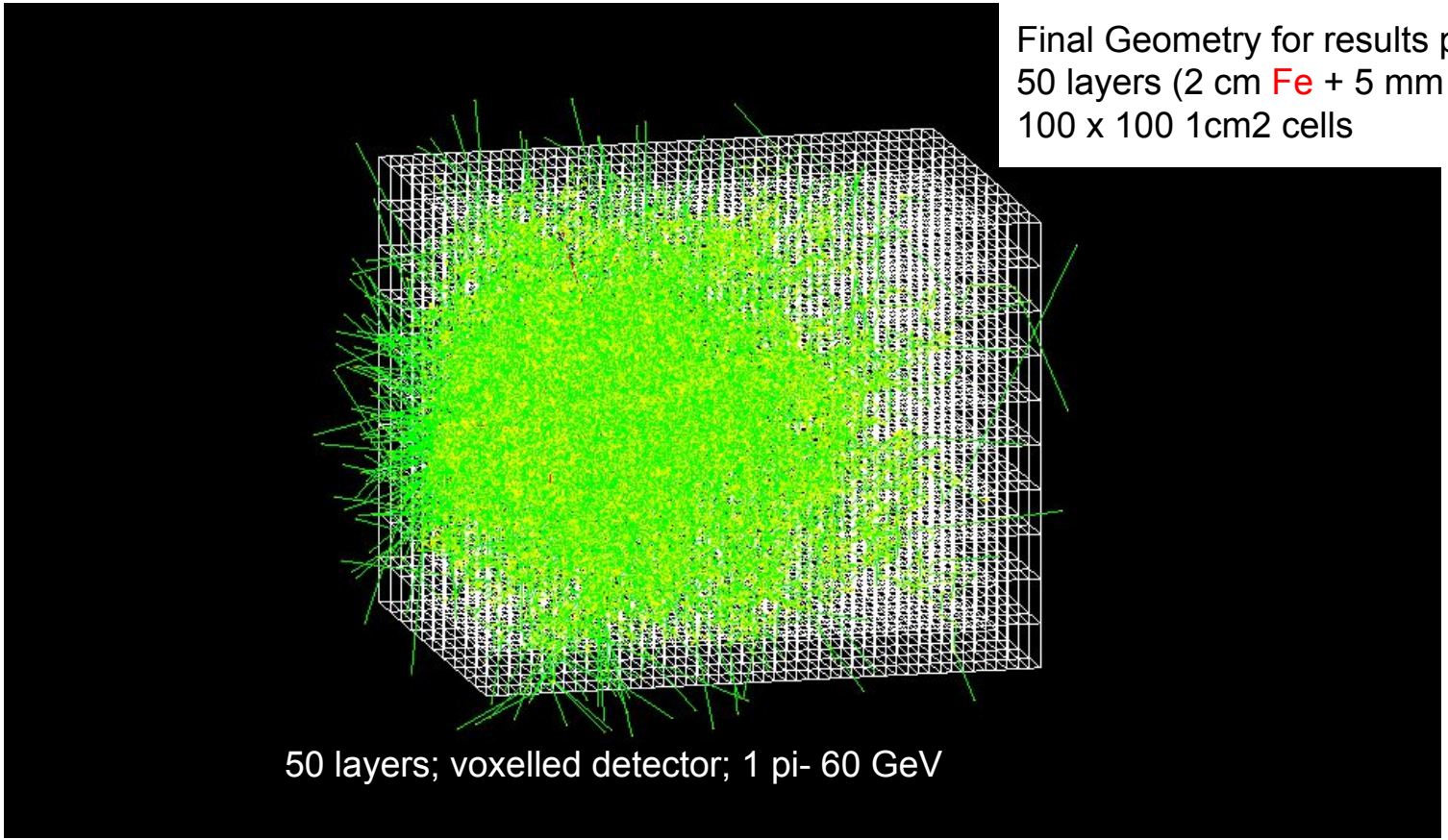
Fit the energy resolution

$$\frac{\sigma}{E[GeV]} = \frac{S}{\sqrt{E[GeV]}} \oplus C$$

to the relation $\frac{\sigma_{rec}}{\langle E_{rec} \rangle}$ as a function of E_{beam}

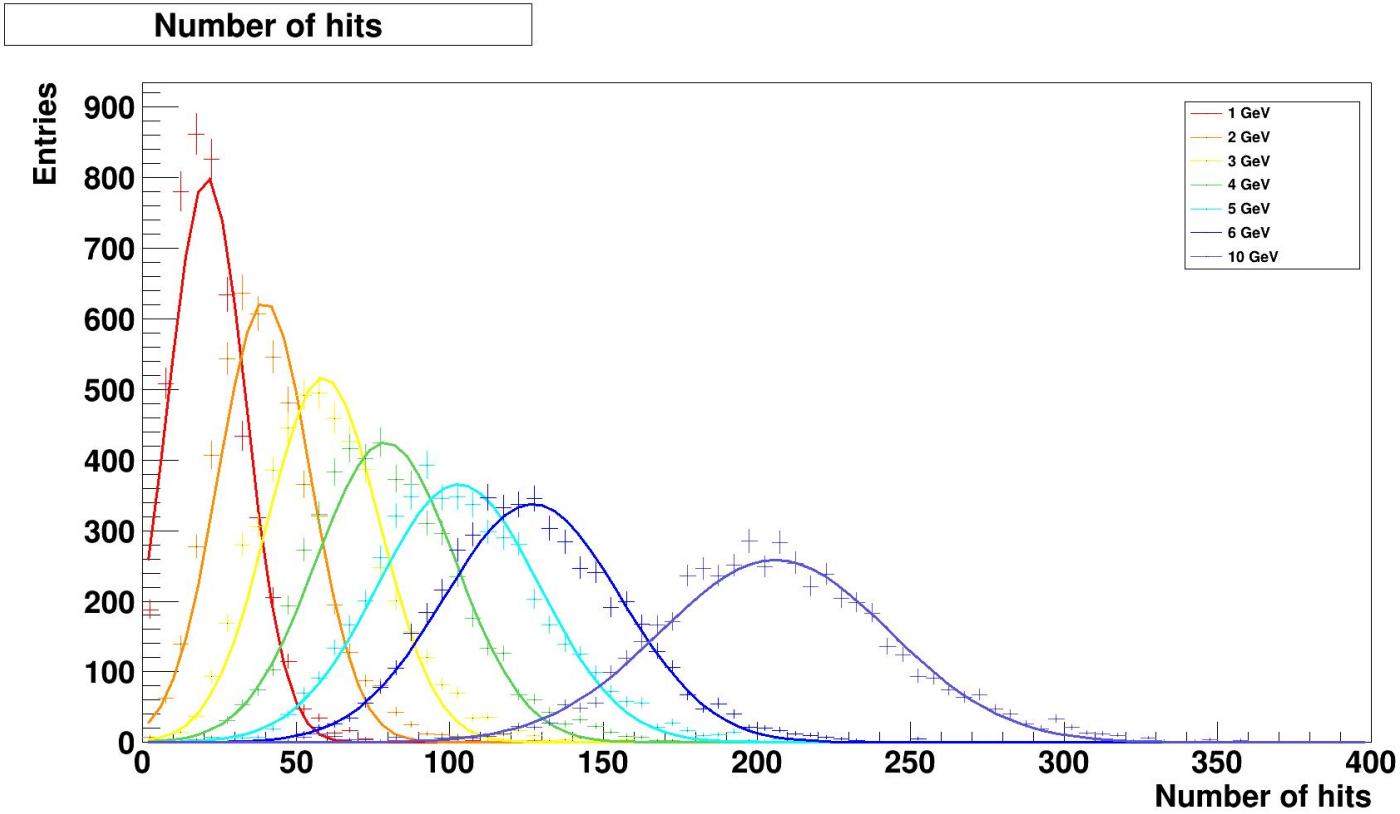
Workflow to get energy resolution

- Simulate pi- beams at different energy (5000 events per beam)
- Save the deposited energy in each cell of the active layer of the calorimeter
- Define hit as cell with an energy deposited > 30 eV
- Get the distribution of the number of hits for each beam energy and extract mean value
- Find **response function** of calorimeter: dependence of <Nhit> wrt Ebeam
- Reconstruct the energy through the inverse response function
- Get <E> and σ from the reconstructed energy distribution to find energy resolution

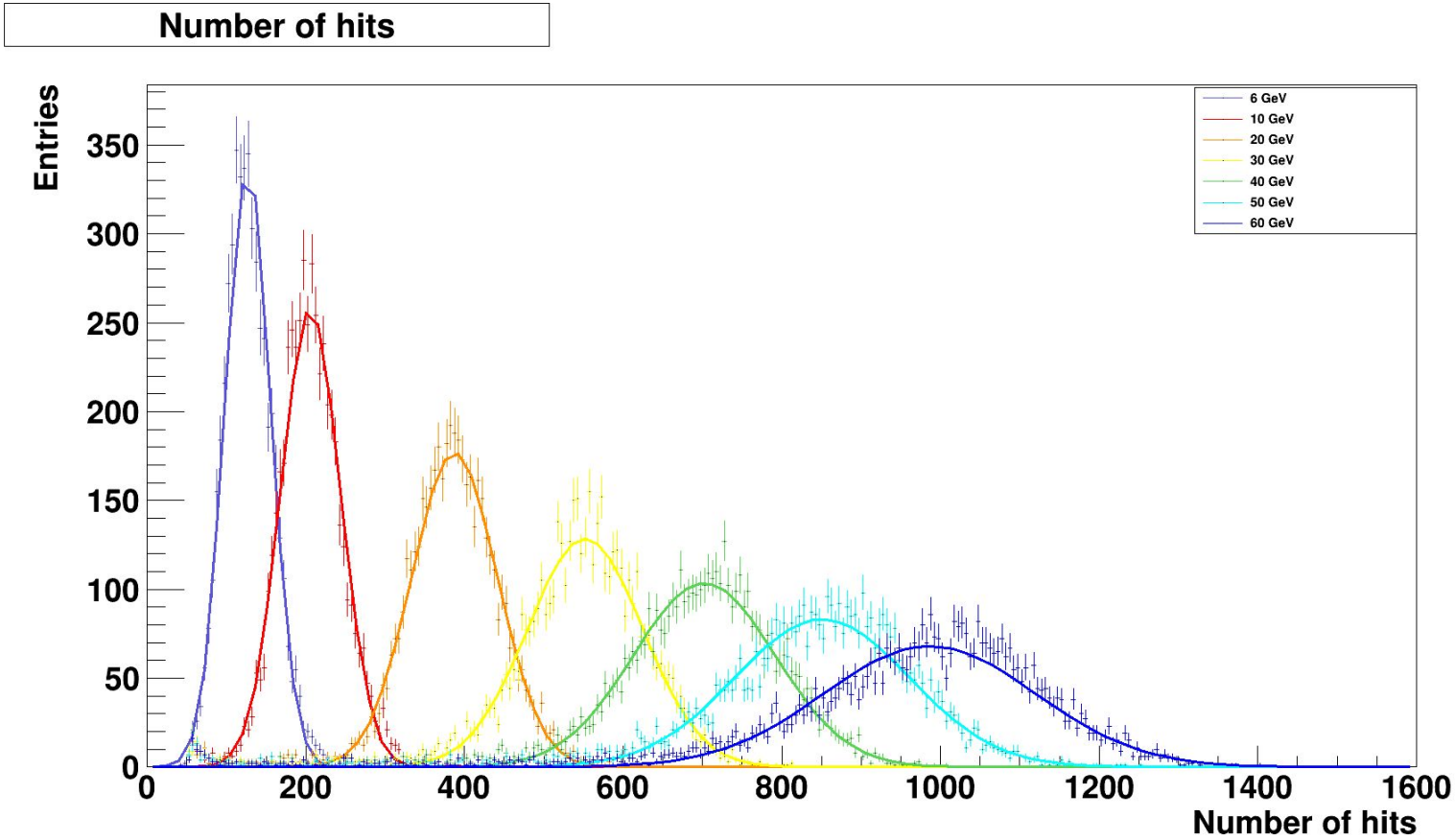


Final Geometry for results presented today:
50 layers (2 cm Fe + 5 mm Ar)
100 x 100 1cm2 cells

Distribution of number of hits for different beam energy values
Gaus Fit to extract <Nhit>



Distribution of number of hits for different beam energy values
Gaus Fit to extract <Nhit>

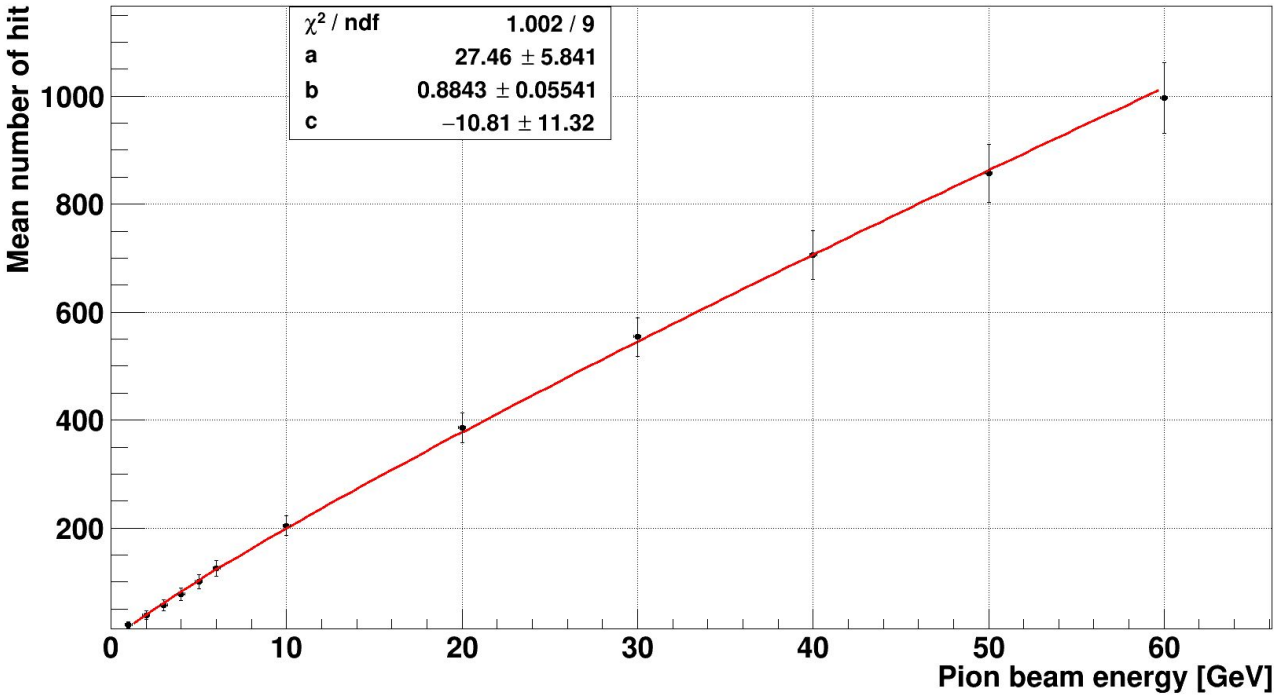


<Nhit> as a function of the energy beam

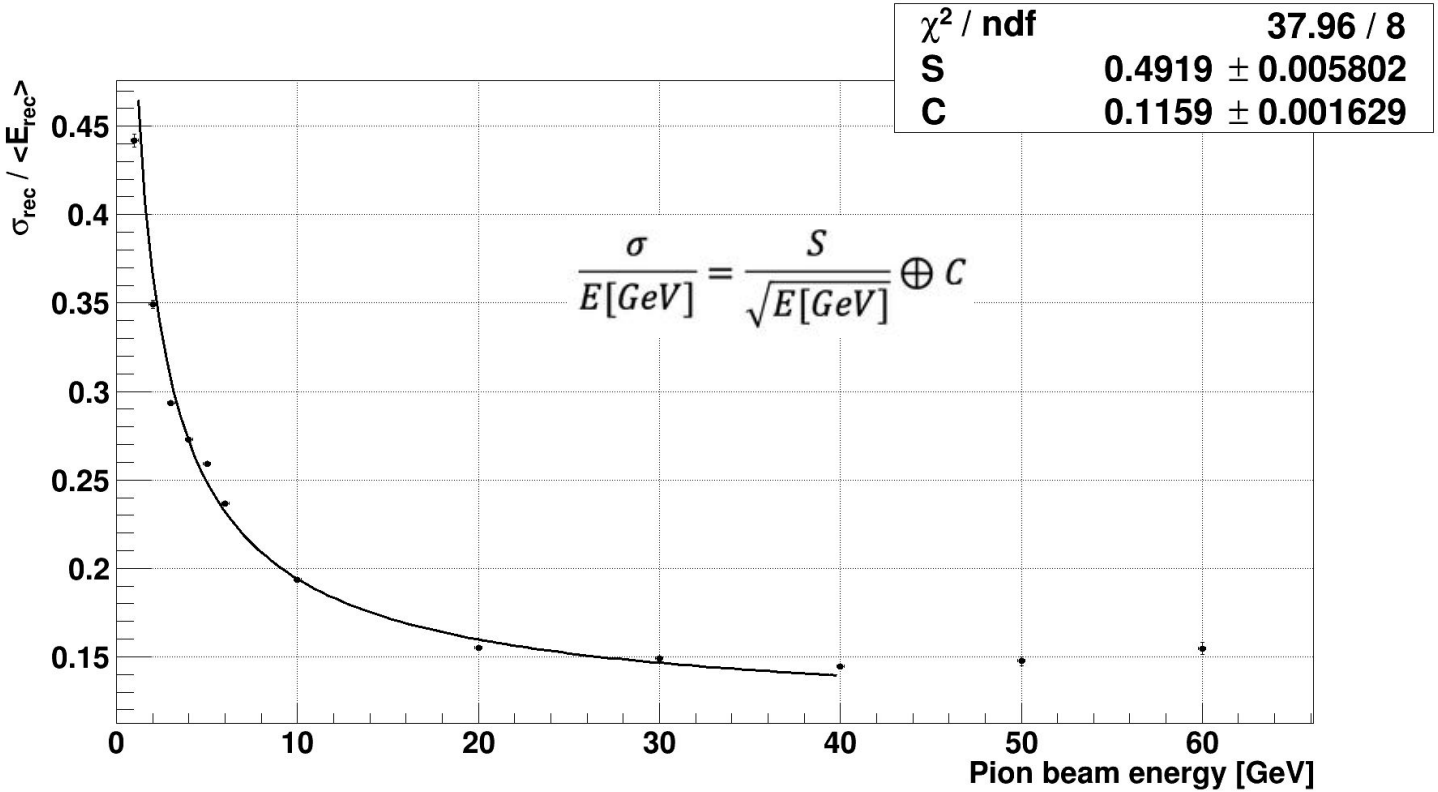
Data fitted with power law

$$\langle N_{hits} \rangle = a \cdot E_{beam}^{b} - c$$

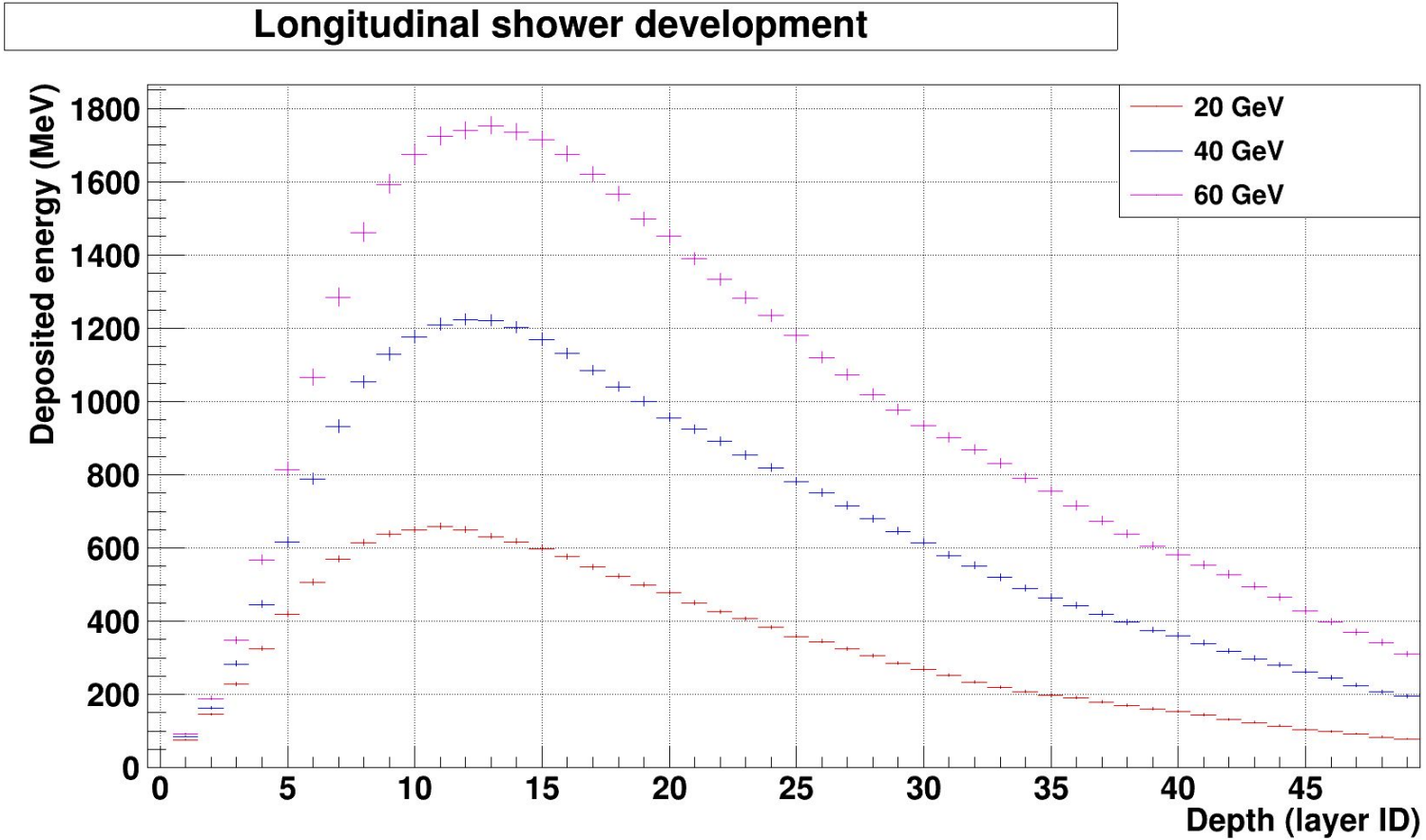
Ref: Repond, CHEF 2013



σ and <E> extracted from the gaussian fit of the distribution of the energy reconstructed

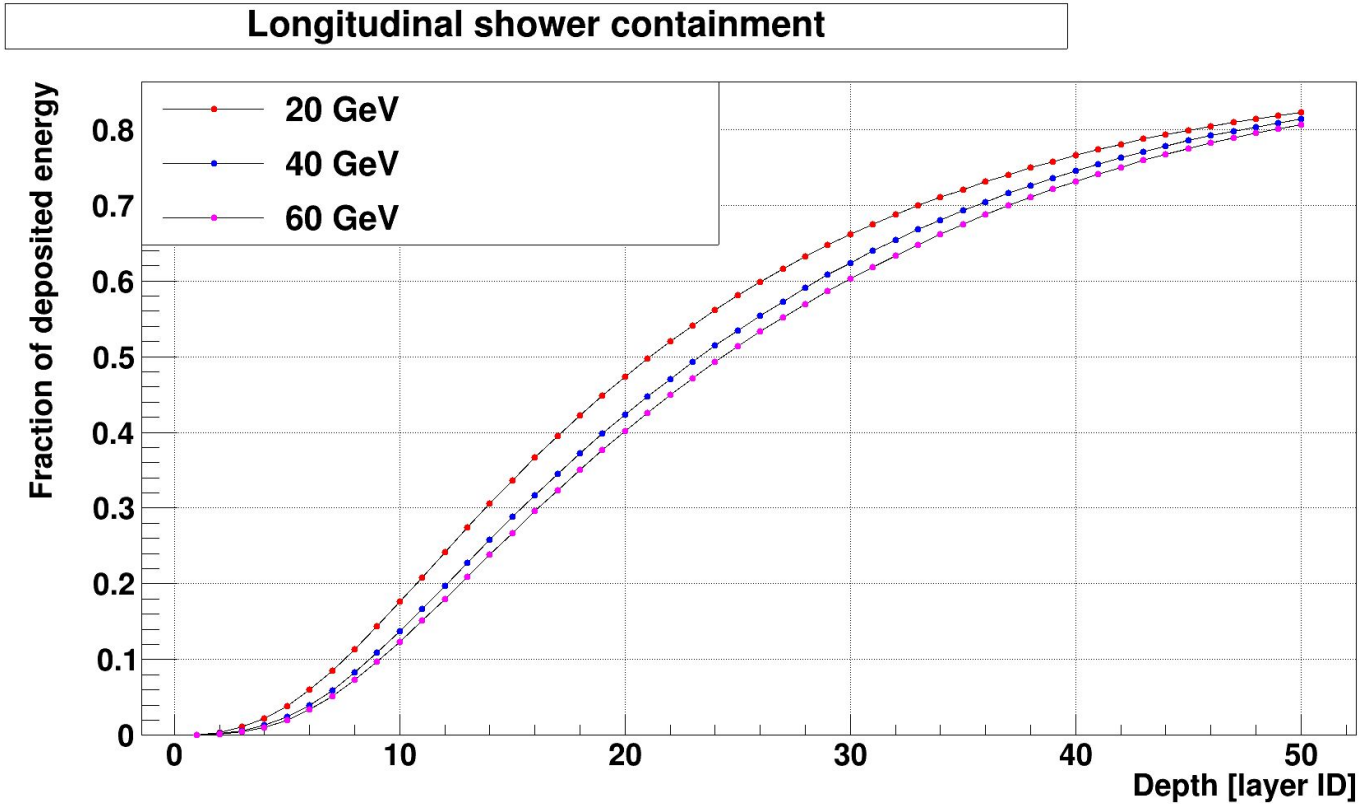


1x1 m2 - 50 layers



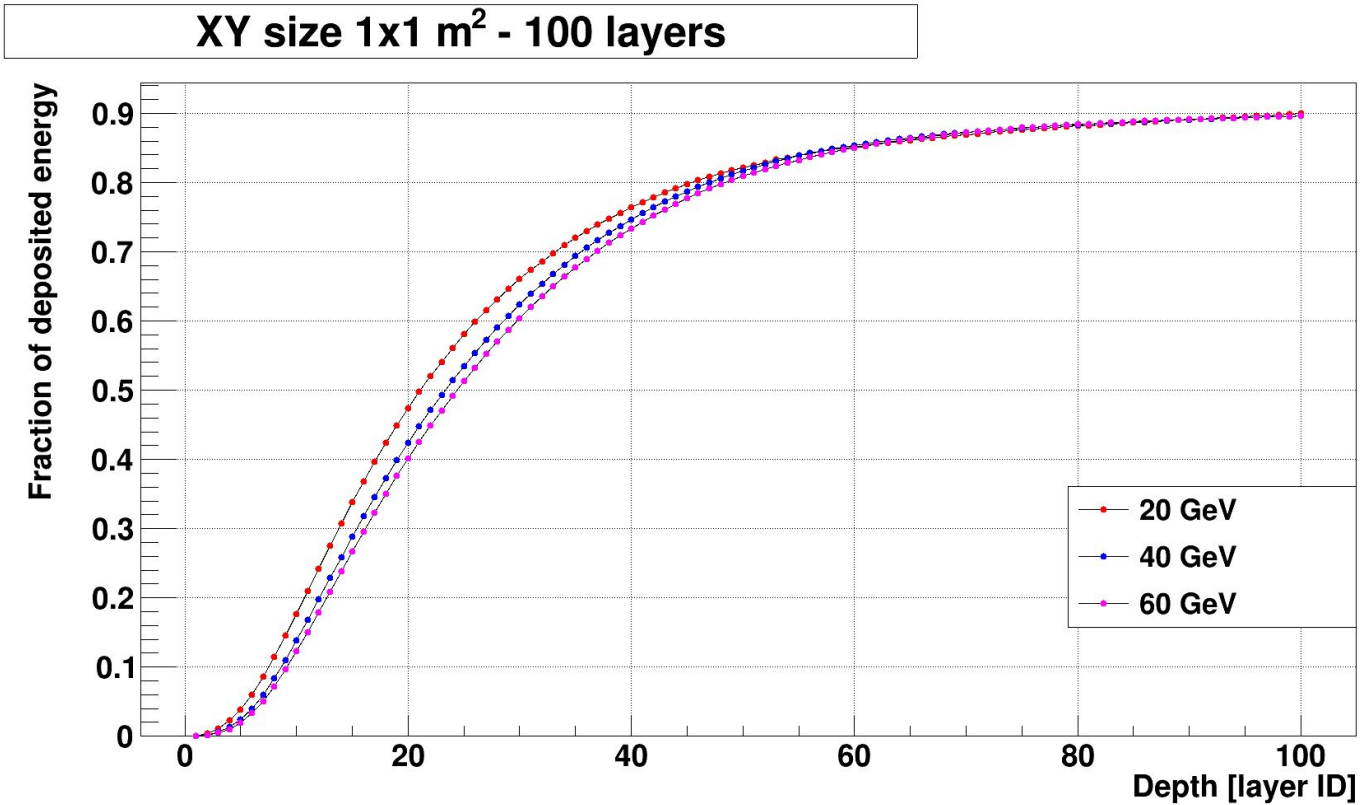
Fraction of deposited energy =

[Eabs + Egap] deposited untill a given layer over the Ebeam

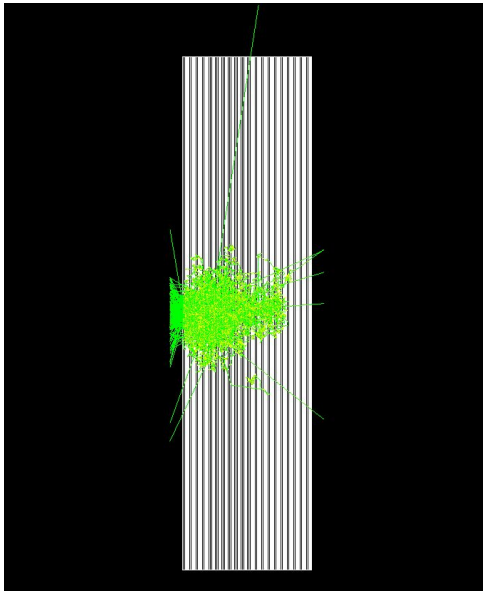


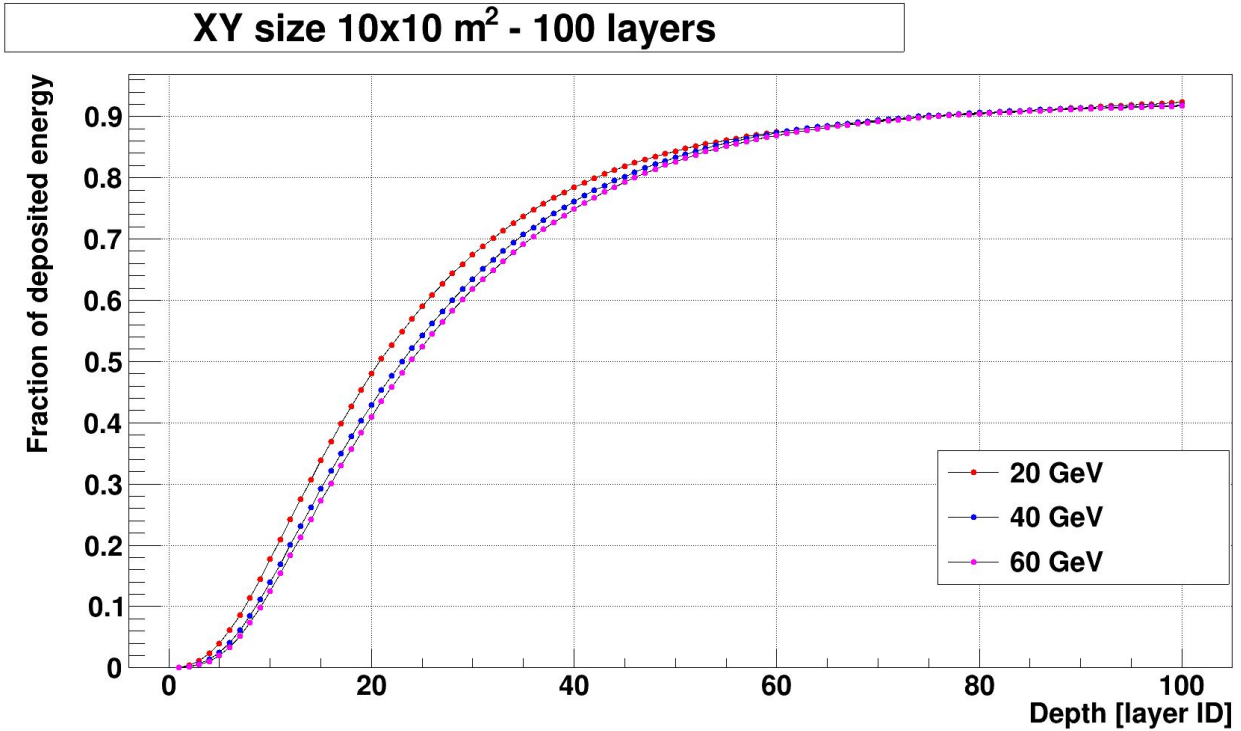
Fraction of deposited energy =

[Eabs + Egap] deposited untill a given layer over the Ebeam

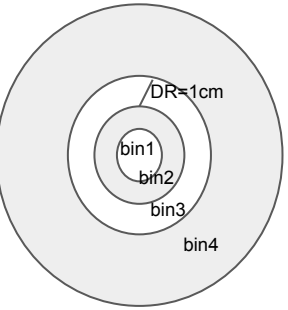


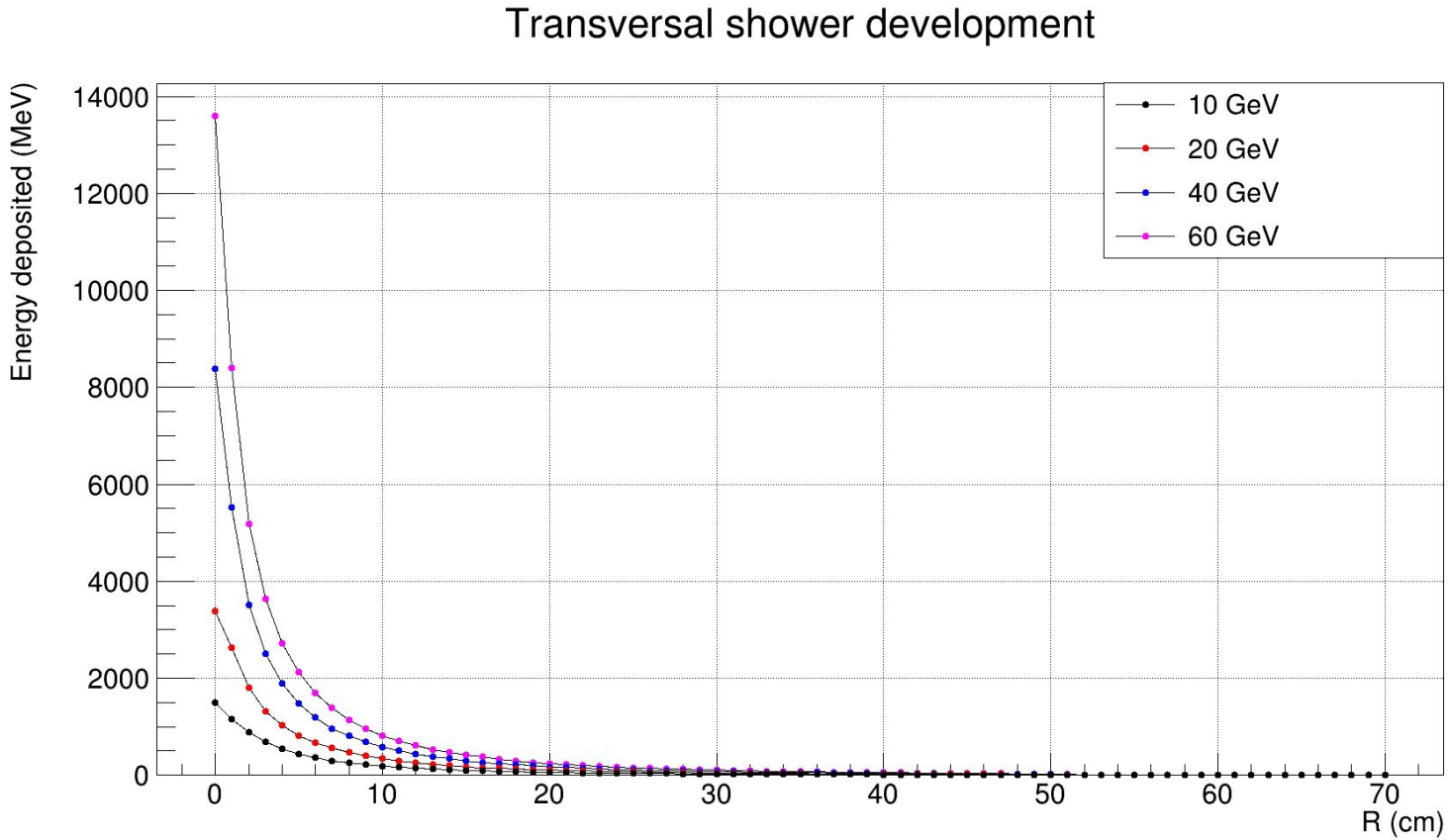
1 pi- of 60 GeV

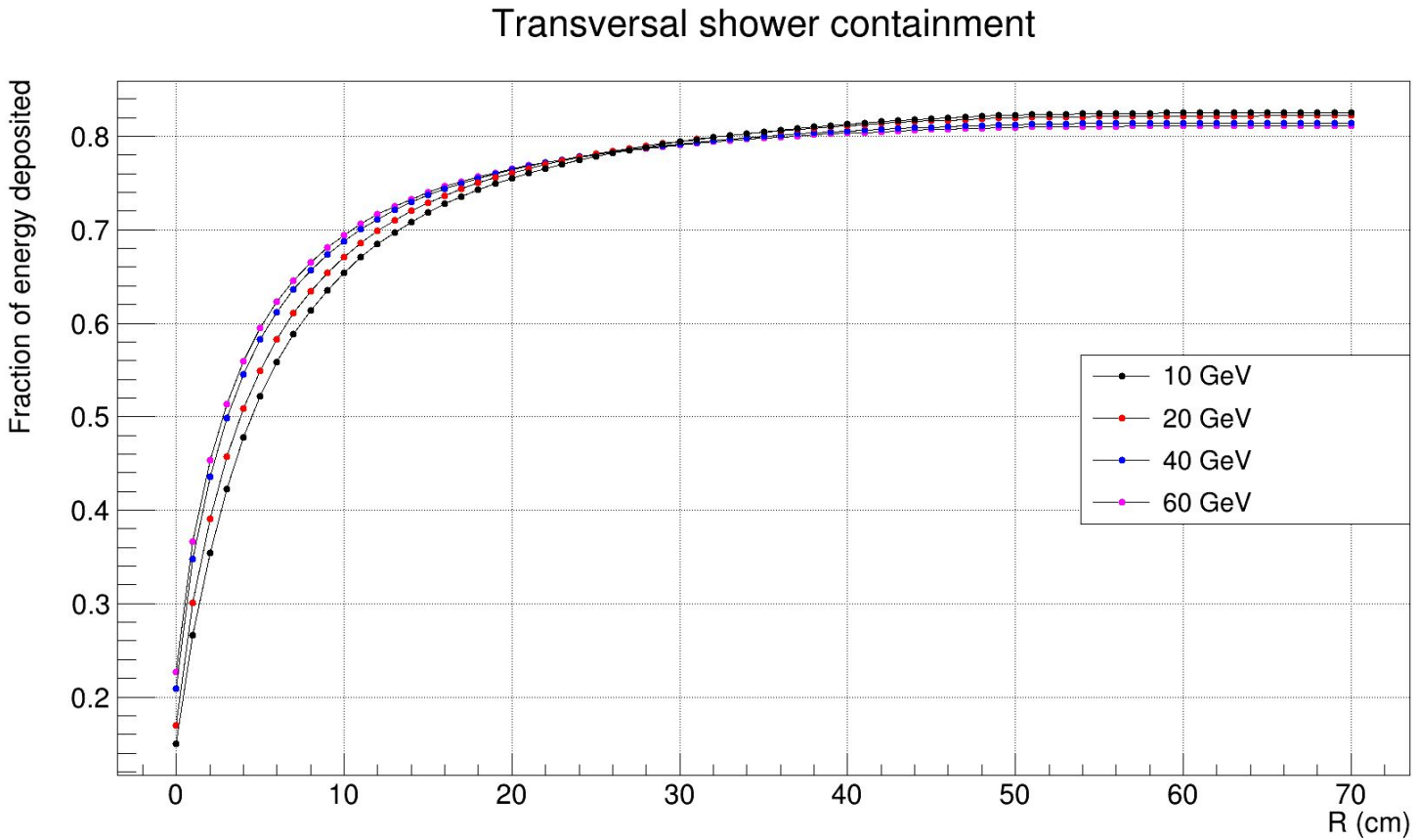



XY size 10x10 m^2 - 100 layers
Fraction of deposited energy
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
20
40
60
80
100
Depth [layer ID]
20 GeV
40 GeV
60 GeV

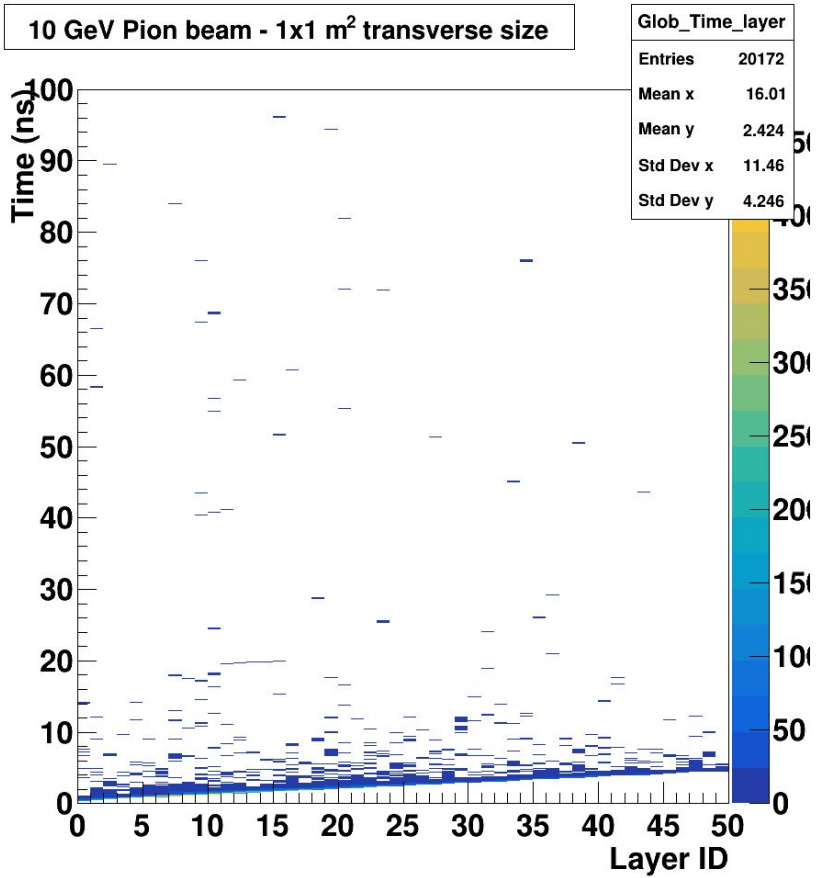
1x1 m2 - 50 layers

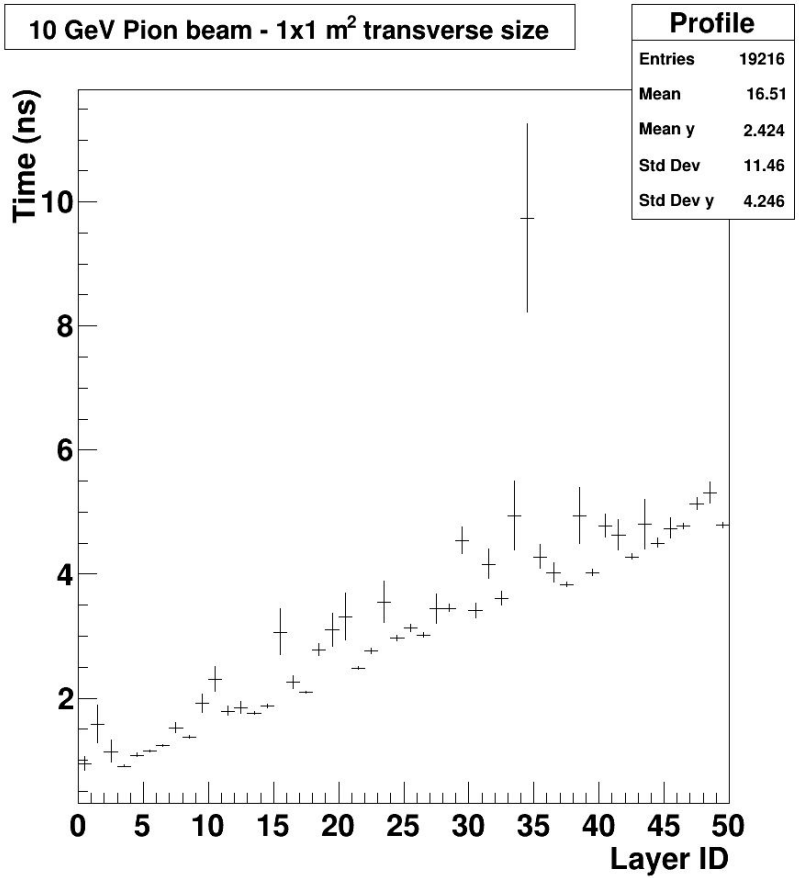




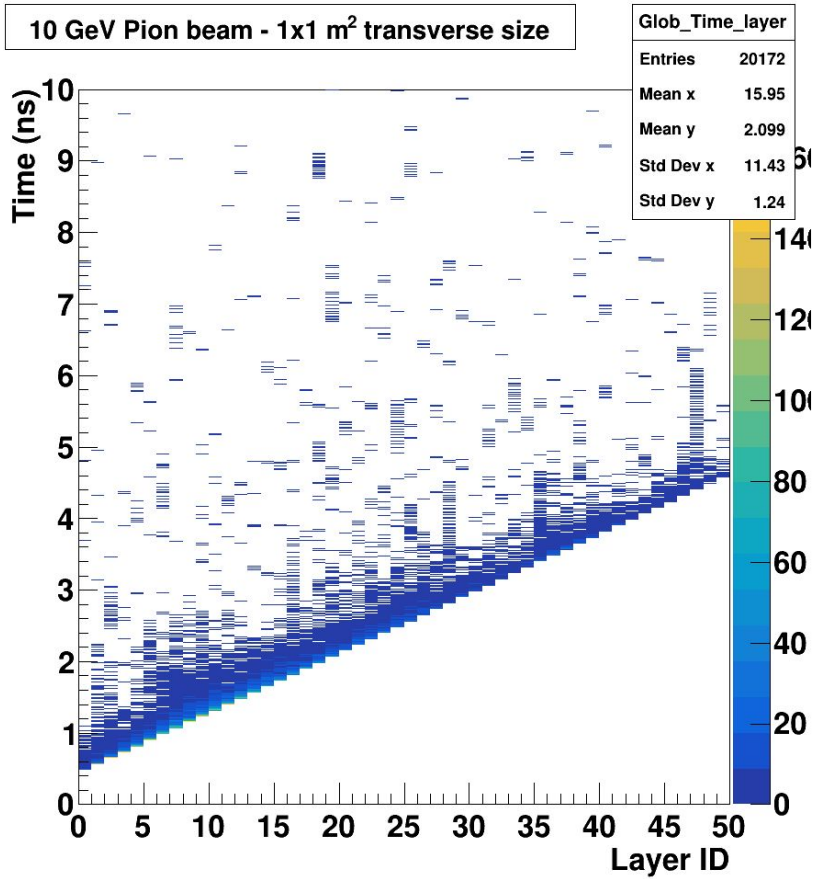

Transversal shower containment
Fraction of energy deposited
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
10
20
30
40
50
60
70
R (cm)
10 GeV
20 GeV
40 GeV
60 GeV

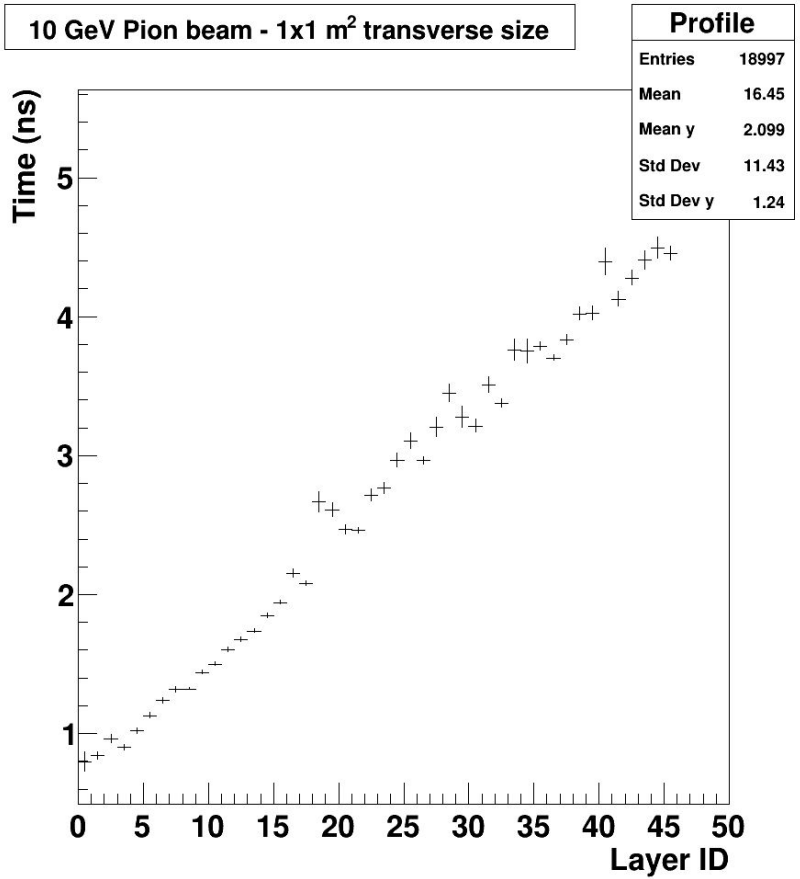
Time development - 10 GeV



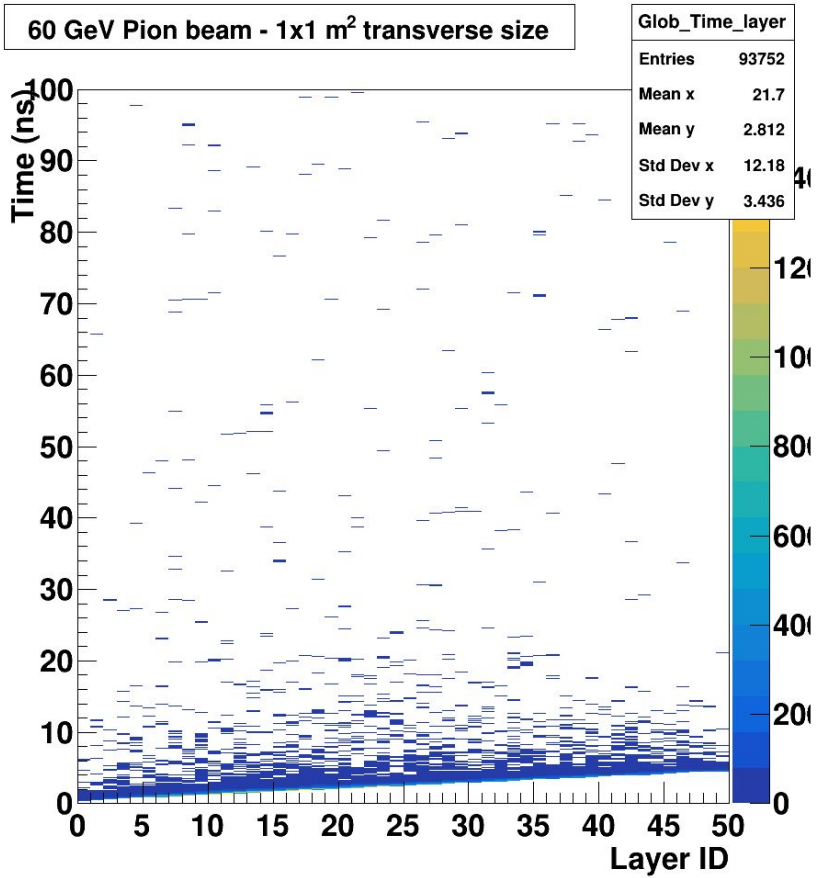


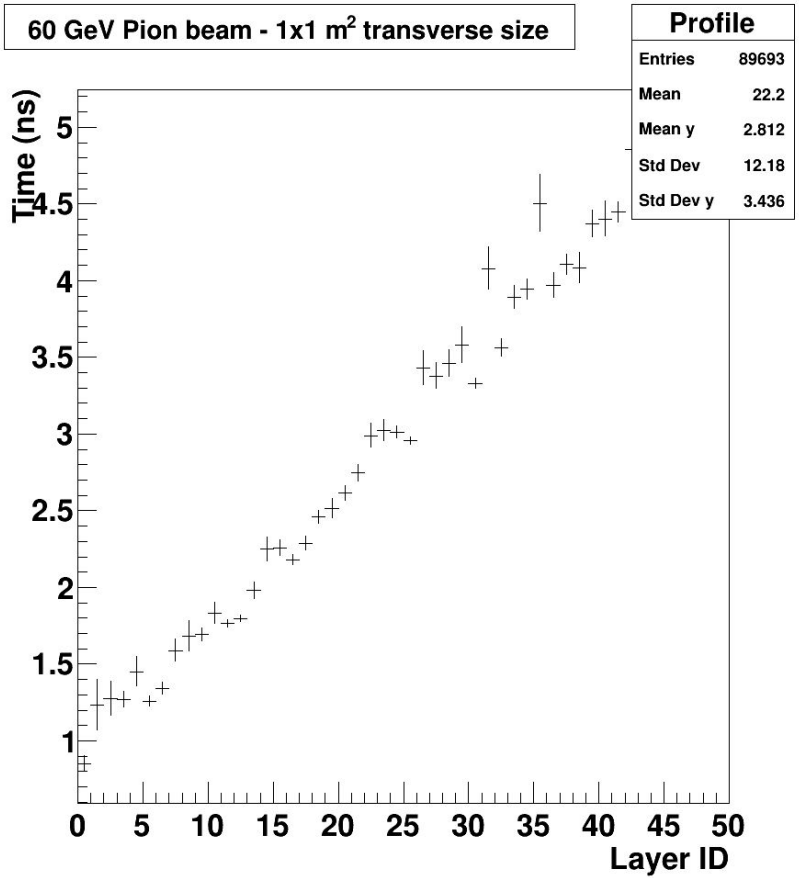
Time development - 10 GeV



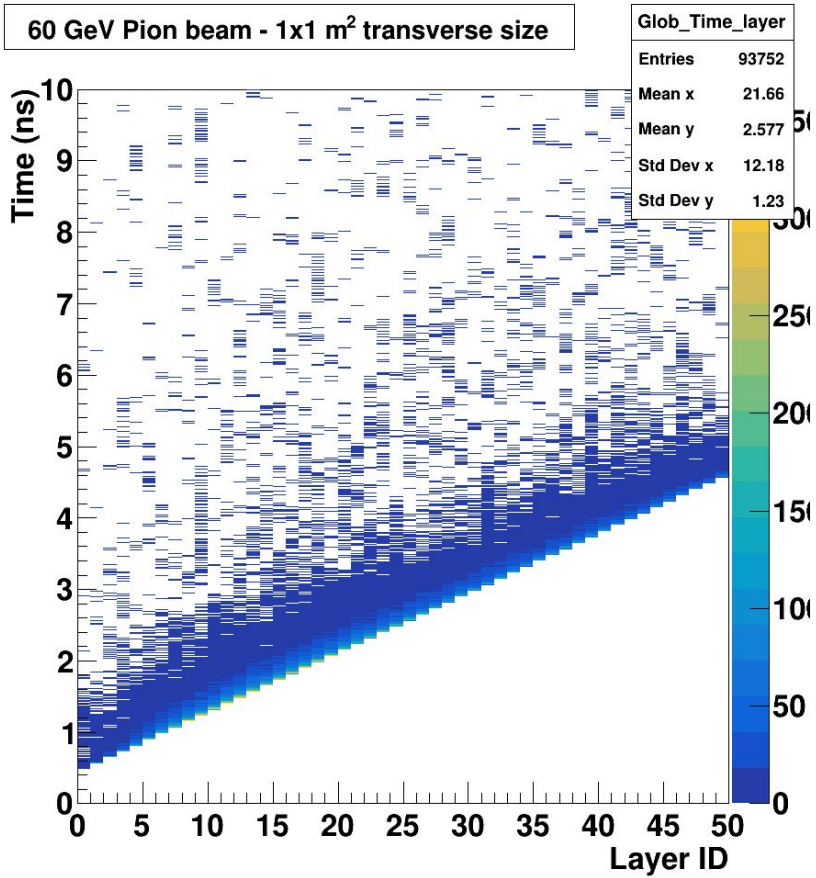


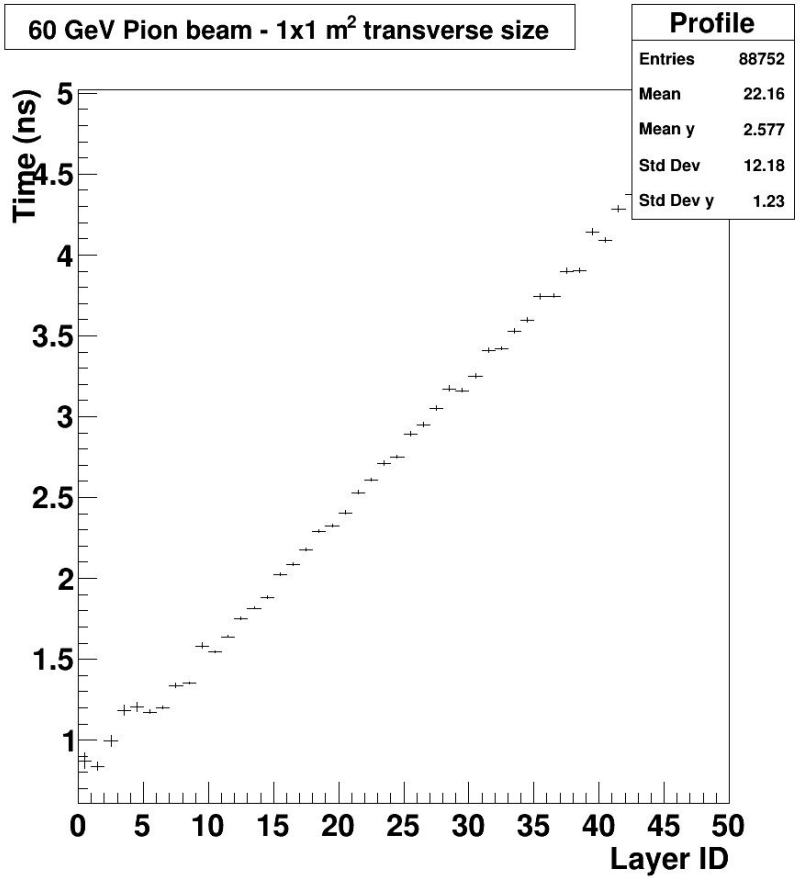
Time development - 60 GeV





Time development - 60 GeV





To do :

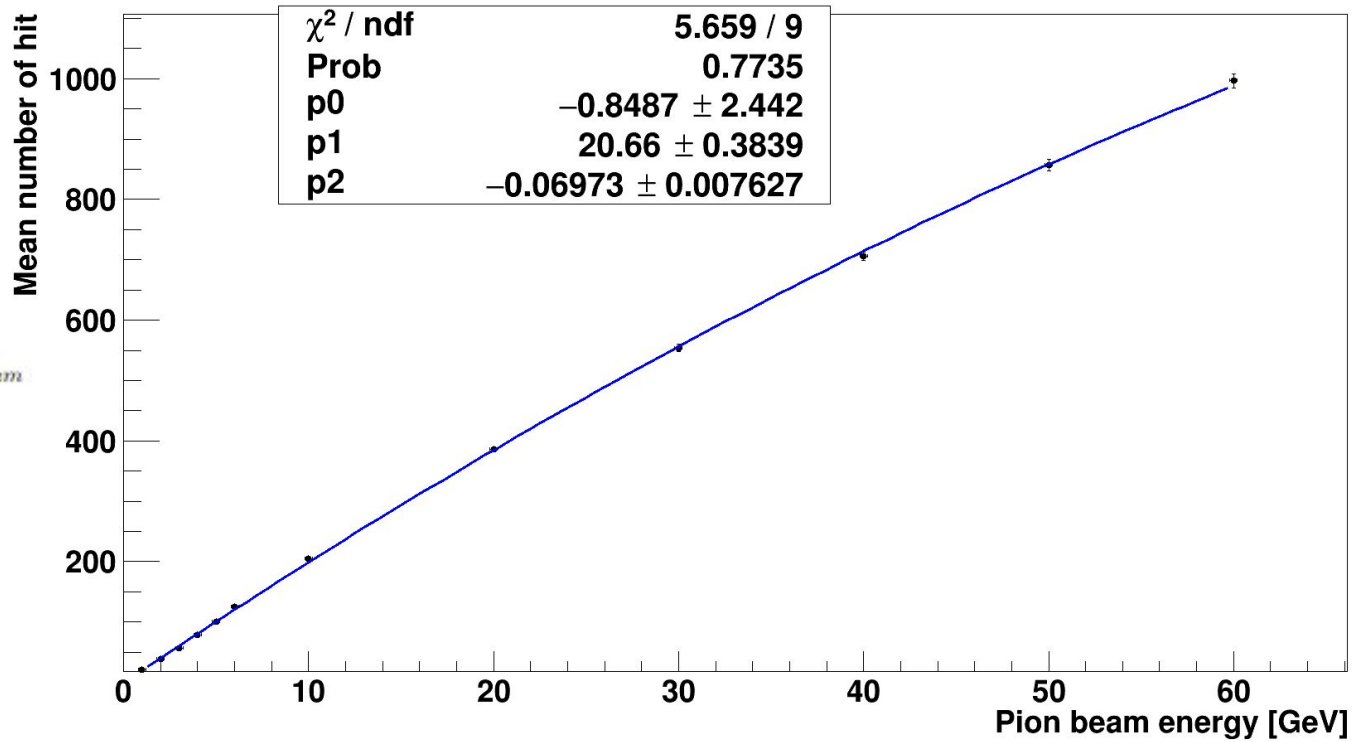
- include PCB in the geometry
- include hit efficiency
- include time distribution

BACKUP

<Nhit> as a function of the energy beam

Data fitted with polynomial function

$$N_{hit} = p_0 + p_1 \cdot E_{beam} + p_2 \cdot E_{beam}^2$$

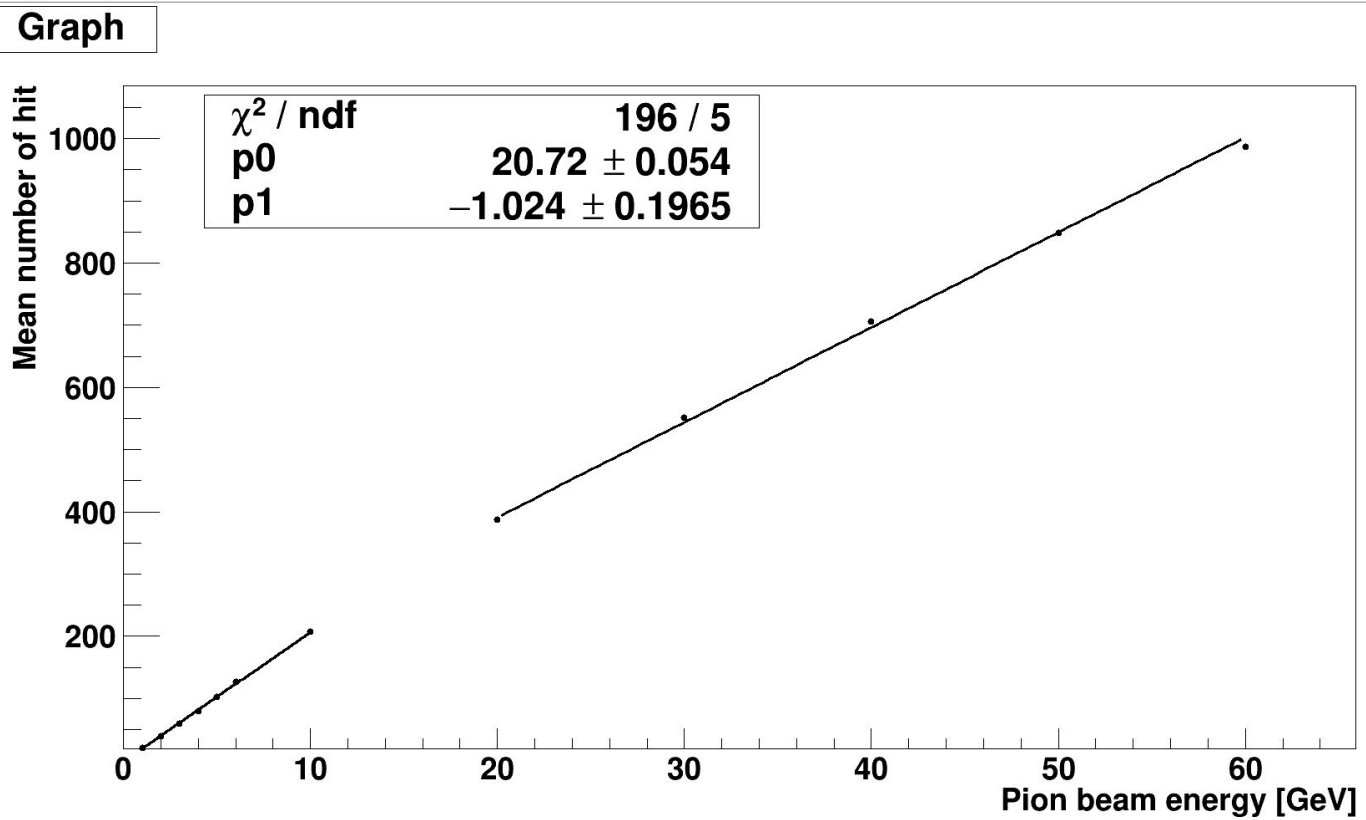


Mean number of hit extracted from the gaussian fit of the hit distribution

Data fitted with linear function

$$\langle N_{hits} \rangle = a \cdot E_{beam}^{b} - c$$

Two different parametrization from low energy (1 - 10 GeV) and high energy (20 - 60 GeV) (to be further adjusted)

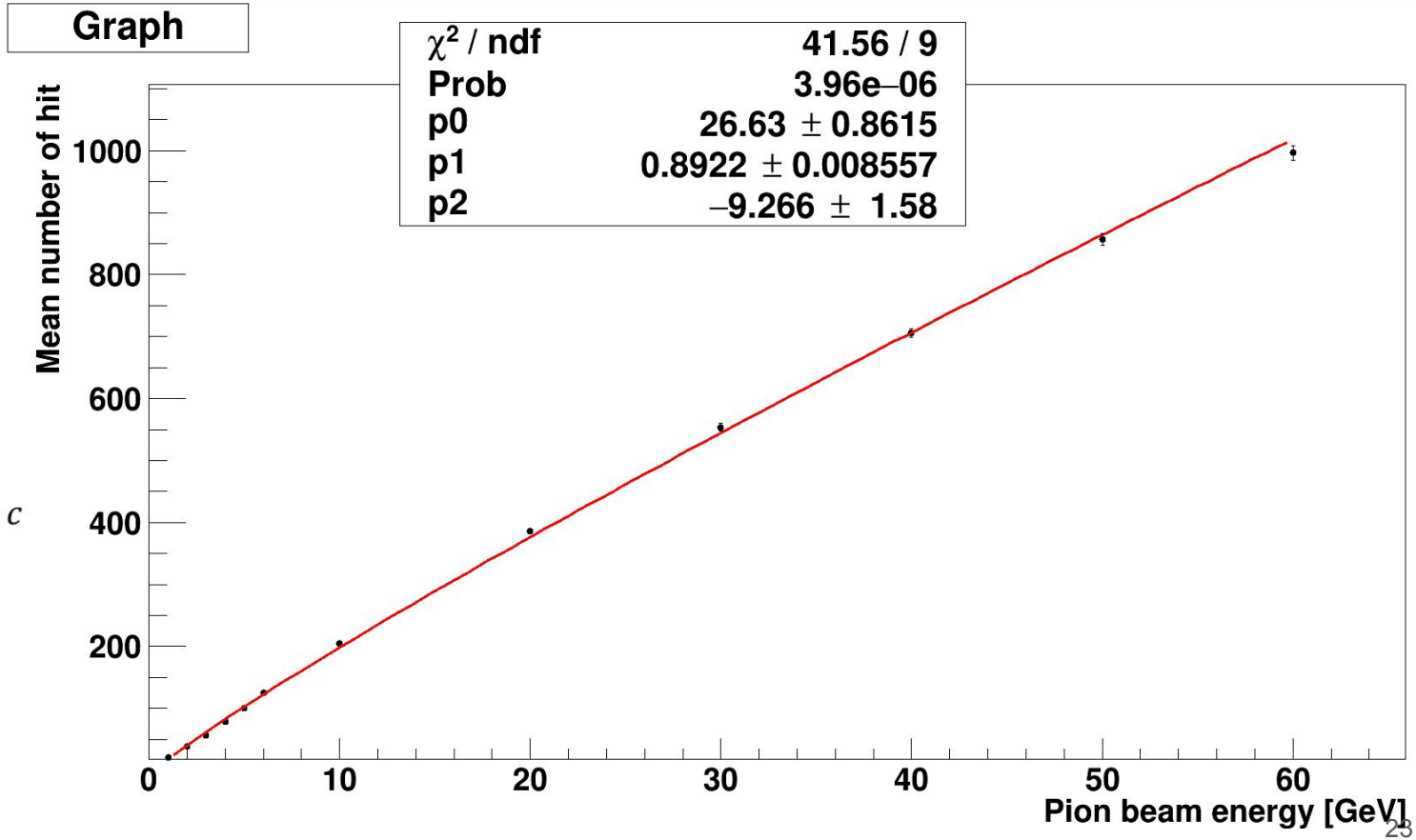


Mean number of hit extracted from the gaussian fit of the hit distribution

Data fitted with function

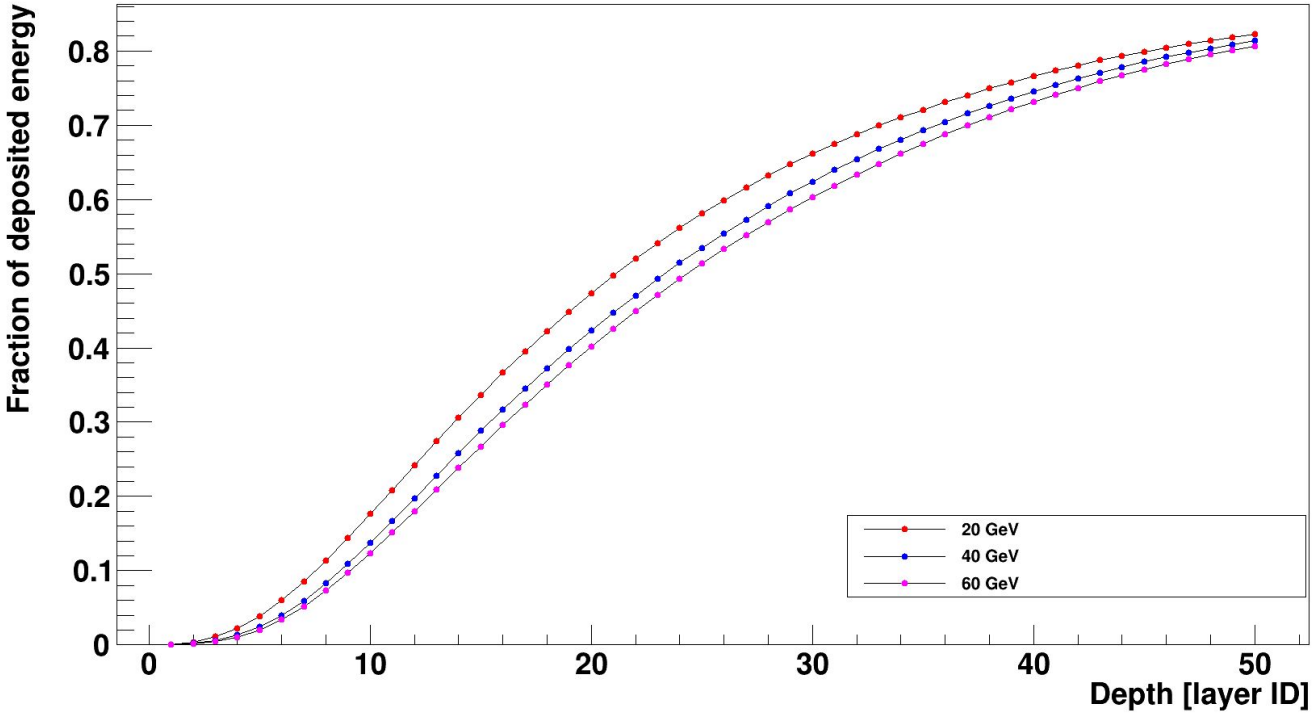
$$\langle N_{hits} \rangle = a \cdot E_{beam}^{b} - c$$

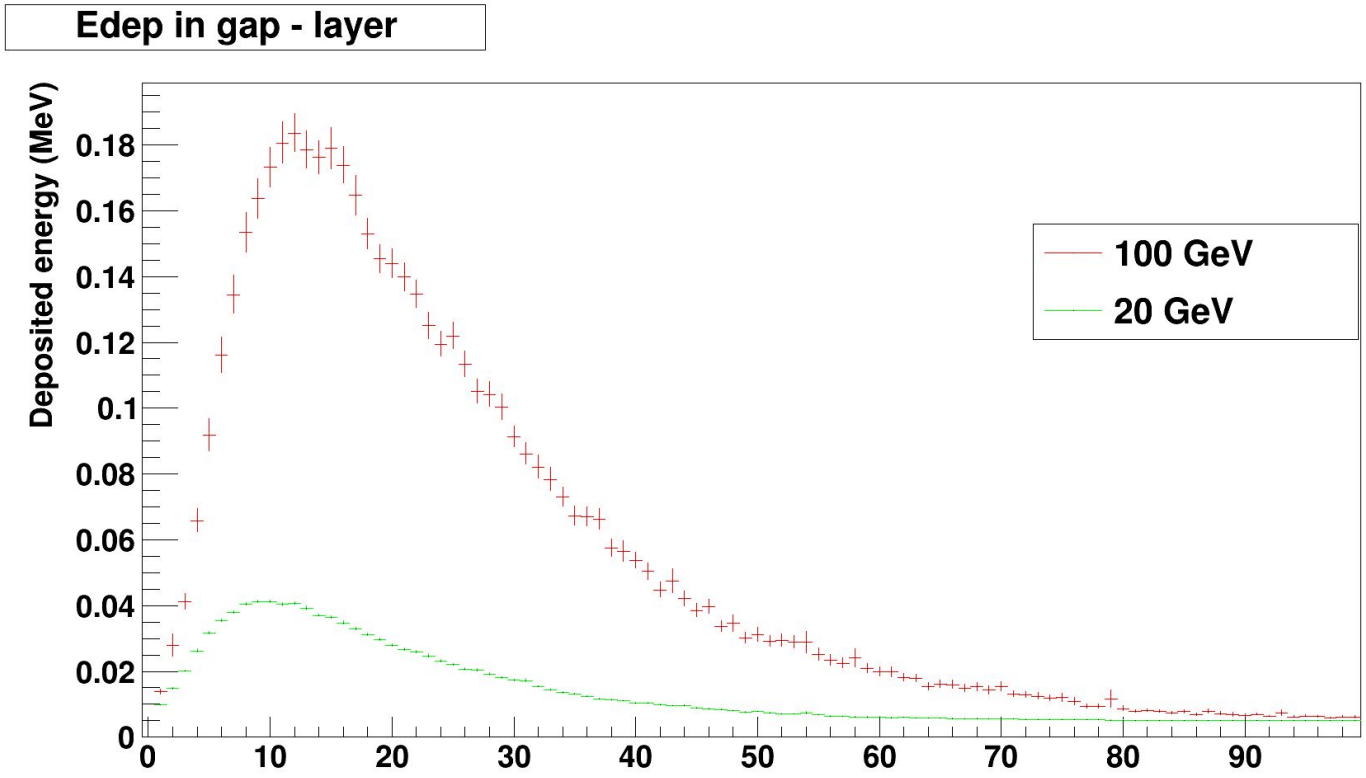
p0 = a
p1 = b
p2 = c



Fraction of deposited energy =

[Eabs + Egap] deposited untill a given layer over the Ebeam





Deposited energy

~88 GeV in abs
~5.5 MeV in gap

~18 GeV in abs
~1.4 MeV in gap